

9 WIND MICROCLIMATE

Introduction

- 9.1 This chapter of the ES assesses the potential impacts and associated likely effects of the proposed development on the local wind microclimate within and around the application site. In particular, it considers the likely effects of wind upon pedestrian comfort and safety and summarises the findings of a Computation Fluid Dynamics (CFD) assessment.
- 9.2 The chapter describes the methods used to assess the potential impacts; the baseline conditions currently existing at the application site and the study area; as well as the potential impacts and likely effects on wind microclimate during construction and at the completed development stage, taking into consideration embedded mitigation measures. Where appropriate, additional mitigation measures required to prevent, reduce, or offset the likely effects, are identified and the chapter concludes with a summary of the likely residual effects.
- 9.3 This chapter is accompanied by the following technical appendices in ES Volume 3:
- Technical Appendix 9.1: Wind Microclimate Results.

Methodology

- 9.4 There is no published guidance for wind microclimate assessment in EIA. Accordingly, the assessment has been informed by the following legislation, policies and published guidance:
- NPPF¹;
 - PPG²; and
 - Reading Borough Local Plan 2019³.
- 9.5 In addition, professional judgment has been applied.

Consultation

- 9.6 No consultations have been undertaken in addition to the formal EIA scoping process. At the time of undertaking this assessment, the EIA Scoping Opinion remains outstanding.

Assessment Scope

- 9.7 The assessment has been based on a series of development parameters, commitments and assumptions, as described in Chapter 2: EIA Process and Methodology; Chapter 4: Proposed Development Description; and Chapter 5: Demolition and Construction Environmental Management. Due to the flexibility being sought in respect of land use classes and associated development scenarios, the wind microclimate assessments has been undertaken of the worst-case massing proposals represented by parameter plan PP-105 (mixed-use scheme).

Technical Scope

- 9.8 The wind microclimate assessment quantifies the expected wind microclimate in pedestrian areas at ground level and at roof top level. The measured wind speed statistics have been benchmarked against

the Lawson Comfort Criteria⁴ to determine the suitability of the proposed development for different pedestrian activities. Strong winds have also been considered.

- 9.9 Existing pedestrian receptor locations around the application site, have been assessed for wind conditions against both their intended use and against the baseline wind conditions. New pedestrian receptor locations introduced by the proposed development have been assessed against their intended use.
- 9.10 For both existing and new receptor locations, where changes to conditions have been measured, the significance of effect for each location have been defined.

Spatial Scope

- 9.11 The study area included existing and cumulative surrounding buildings and terrain covering a 300 m radius from the application site boundary. The extent of the virtual wind tunnel was 1,800 m long by 1,100 m wide by 350 m tall and was rotated with wind direction.

Temporal Scope

- 9.12 The assessment has considered the following three configurations:
- Existing baseline;
 - Existing baseline + proposed development; and
 - Existing baseline + proposed development + cumulative schemes.

Baseline Characterisation Method

Desk Study

Meteorological Data

- 9.13 Wind data for the Reading area was sourced from MeteoBlue via SimScale. MeteoBlue data is based upon over 30 years of historical weather simulation data assembled in continuous hourly resolution.

Field Study

- 9.14 A field study was not required to inform the assessment.

Assessment Method

Methodology

Demolition and Construction

- 9.15 Typically for a wind microclimate assessment, the likely effects during demolition and construction would be assessed using the professional judgement of an experienced wind engineer. The assessment is based on the background wind climate at the application site and on an understanding of the effects of wind in the built environment. This approach is taken on the basis that the on-site activity during this time (i.e. construction activity) is less sensitive to wind conditions than when the proposed development is completed and occupied (which would include entrance and amenity space, for example).

¹ Secretary of State for Ministry of Housing, Communities and Local Government, 2019. National Planning Policy Framework.

² <https://www.gov.uk/government/collections/planning-practice-guidance>

³ Reading Borough Council, 2019. Reading Borough Local Plan. RBC.

⁴ Lawson TV (2001). Building Aerodynamics. Imperial College Press.

9.16 A qualitative assessment of the wind microclimate during demolition and construction has therefore been undertaken and has been based on professional judgement (informed by an assessment of the background wind microclimate in the area, the results of the tested configurations for the baseline and completed development scenarios, and the wind specialist’s experience of assessing wind in the built environment).

Completed Development

- 9.17 To predict the local wind environment associated with the completed development and to determine the resulting pedestrian comfort within and immediately surrounding the application site (the study area), testing using SimScale Computational Fluid Dynamics Software (CFD) of the proposed development has been undertaken.
- 9.18 The mathematical solver employed by SimScale is the Lattice Boltzman method (LBM). The LBM solver is very well suited to wind microclimate assessments allowing for the accurate resolution of complex geometries in an efficient time frame.
- 9.19 CFD simulation is a well-established means of assessing the pedestrian wind microclimate. It has been used to assess conditions within, and immediately surrounding, the proposed development. CFD enables the turbulent wind conditions at the application site to be quantified and classified in accordance with the widely accepted Lawson Comfort Criteria, as described below.
- 9.20 Three 3D computer geometry models were constructed representing the following three configurations:
- Configuration 1: Existing baseline;
 - Configuration 2: Existing baseline + proposed development; and
 - Configuration 3: Existing baseline + proposed development + cumulative schemes.
- 9.21 The proposed development is expected to alter the pedestrian use of spaces and so a direct comparison of the existing wind conditions with those on the developed site may not be suitable. For example, it may be considered a negligible change where conditions suitable for walking in the existing climate remain suitable for walking following the completed development. However, mitigation would be required should the use of the space have changed to a building entrance and standing conditions would be more appropriate. The new pedestrian activities for a developed site should therefore be considered.
- 9.22 For each of the configurations, the model also included ground topography such that local wind effects are accurately represented. Minor geometrical details (such as street furniture, foliage, rooftop plant, etc.) were not included in the CFD models. This simplified model geometry provides a worst-case scenario.
- 9.23 In total 16 wind directions were used to assess wind microclimate in terms of pedestrian comfort. Strong winds, defined as wind speeds in excess of 15 m/s for more than two hours have also been included in this assessment and are discussed at the end of the results.
- 9.24 The methodology used to quantify the pedestrian level wind environment for the above configurations comprised the following:
- Step 1: The geometry of the study area, proposed development, and cumulative schemes were assembled in the 3D computer models of the three configurations.
 - Step 2: The meteorological data for the application site was used and appropriate wind exposure classifications for each direction were applied.
 - Step 3: The wind speed, direction and frequency at pedestrian level were modelled for all wind directions.

- Step 4: The wind speed results were compared with respect to the Lawson Comfort criteria and a statistical summary of all wind directions was produced as a single plot for the application site and study area.
- Step 5: Strong winds were analysed using Lawson LDDC criteria for assessing unsafe conditions.

9.25 The prevailing wind direction for the application site is south-westerly (SW) to south-south-westerly (SSW). Additionally, during spring time, a strong north-easterly (NE) to east-north-easterly (ENE) wind results in a smaller secondary peak in the wind rose, as shown in Figure 9.1.

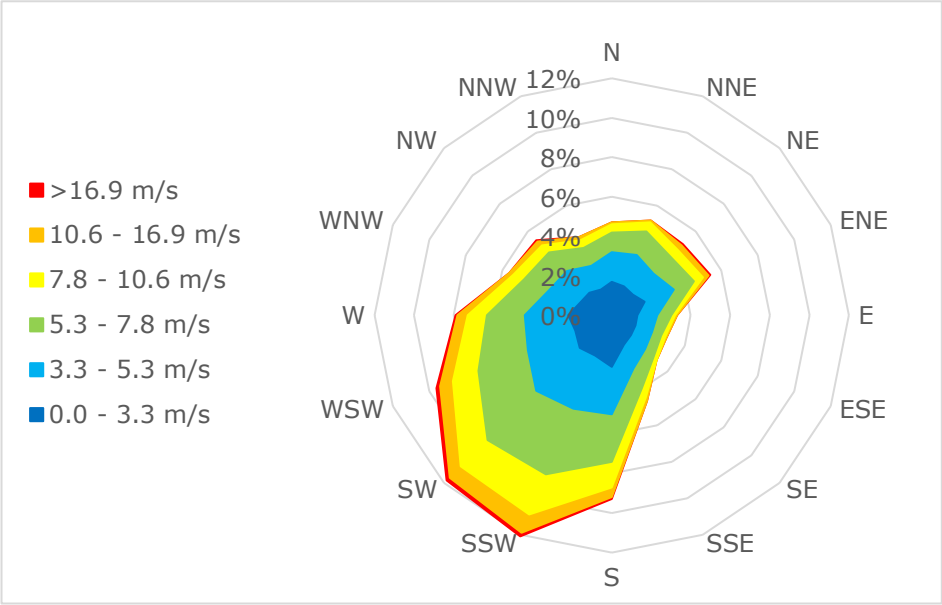


Figure 9.1: Annual Average Wind Rose for Reading, UK⁵.

- 9.26 The region around the application site was assessed for ground roughness using BREVe software with the resulting wind exposures applied to the wind data within SimScale using wind engineering standard EN 1991-1-4. The surrounding terrain was classified as either Suburban (III) or Urban (IV) as appropriate.
- 9.27 The wind profile for Reading is dominated by south-south-westerly and south-westerly winds, 191° to 236° on the cardinal coordinate system, which is common for much of the south of England. The wind levels are generally higher during the winter months than the summer months. However, the wind rose is largely the same for all seasons. There are periods where north-easterly wind and westerly winds are the prominent wind direction. These directions typically result in a colder wind, so it is important that at least 12 wind directions are considered for detailed assessment and not just south-westerly winds. Therefore, 16 equally distributed wind directions were resolved for this assessment.
- 9.28 Throughout this assessment the wind data used is for an annual average. All Lawson plots account for 16 wind directions which include prevailing winds from summer and winter season conditions combining all seasons in one result. This provides a worst-case result, combining the strongest winds from all seasons. The combination of data combining a high resolution of wind directions with wind data directly for the Reading area, provides a robust wind data set for undertaking wind microclimate assessment and planning for this stage of development.
- 9.29 The CFD simulations were run across the three geometries, each for 16 unique wind directions using the wind data defined for the application site and direction. The simulation provides transient flow results including gusts. These results were then averaged at a 1.5 m height above ground level (and roof

⁵ Compiled from MeteoBlue simulated data for Reading

- top level) for velocity. A statistical surface solution, representing a single result which combines all wind directions was then derived, and the Lawson Assessment Criteria applied to this result.
- 9.30 The results of the assessment criteria are displayed on coloured “heat” maps. With blues representing calm wind conditions (suitable for sitting), and red colours representing strong wind conditions (suitable for walking). The colour plots allow easy identification of wind microclimate conditions across the application site and proposed development.
- 9.31 Traditional wind tunnel wind microclimate assessments rely upon many sensors positioned across the model to measure wind speed at these discrete sensor positions. The effects at these individual points are then reported on. CFD simulation is not limited by individual sensor points. Rather the results are contour mapped allowing results to be observed at any point in the test area. However, a “measurement location” approach is often expected and can be helpful to describe areas. As such, a series of measurement locations (1-50) have been defined across and around the application site and proposed development to assist with analysis and discussion as shown in Figure 9.2. These measurement locations are considered to give an accurate representation of the wind conditions across the application site and proposed development to reflect key receptor locations. Further details including images of the models used are provided in Technical Appendix 9.1.



Figure 9.2: Wind Assessment Measurement Locations

Lawson Comfort Criteria

- 9.32 The Lawson Comfort Criteria (LCC) has been established and industry recognised for over 30 years as a way to assess wind conditions and measurements. The LCC seeks to define the reaction of an average pedestrian to the wind, as described below. If the measured wind conditions exceed the threshold wind speed for more than 5 % of the time, then they are unacceptable for the stated pedestrian activity and the expectation is that there may be complaints of nuisance or people would not use the area for its intended purpose.

- 9.33 The LCC sets out six pedestrian activities and reflect the fact that less active pursuits require more benign wind conditions. The six categories presented in Table 9.2 are; outdoor dining, sitting, standing, strolling, walking and uncomfortable, in ascending order of activity level. In other words, the wind conditions in an area for sitting need to be ‘calmer’ than a location that people merely walk past. Strolling can be considered a more “leisurely” walking pace, for example a park amenity space where the user would like to spend time. The walking classification can be considered more of a “business” walking pace, for example along a main road where the user may not want to dwell for long. The coloured key in Table 9.2 corresponds to the presentation of CFD test results described later in this chapter.

Table 9.2: Receptor Sensitivity Criteria				
Key		Comfort Category	Threshold	Description
	A	Outdoor Dining	0-2 m/s	Light breezes desired for outdoor restaurants
	B	Sitting	0-4 m/s	Light breezes seating areas where one can read a paper or comfortably sit for long periods
	C	Standing	4-6 m/s	Gentle breezes acceptable for main building entrances, pick up / drop-off points and bus stops
	D	Strolling	6-8 m/s	Moderate breezes that would be appropriate for strolling along a city / town centre street, plaza or park
	E	Walking	8-10 m/s	Relatively high speeds that can be tolerated if one’s objective is to walk, run or cycle without lingering
	U	Uncomfortable	>10 m/s	Winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended

Target Conditions

- 9.34 Given the mixed-use nature of the proposed development, the desired wind microclimate would be expected to have areas acceptable for sitting, standing and strolling use. A description of the required comfort categories for the intended use in accordance with Table 9.2 is given in Table 9.3.

Table 9.3: Target Wind Conditions for Intended Uses		
Intended Use	Target Wind Condition Summer	Target Wind condition Winter
Building Entrances	Standing	Standing
Public Amenity Areas	Sitting / Standing	N/A (seasonal use and weather dependent)
Balconies and Roof Terraces	Sitting / Standing	N/A (seasonal use and weather dependent)
Thoroughfares	Strolling	Strolling
Pedestrian Crossings	Walking	Walking
Bus Stops	Standing	Standing

- 9.35 For public amenity spaces, the target wind condition is sitting during the summer months. However, as use is expected to be seasonal for these spaces, there is no specific target for the winter months. If the amenity area is large with many different locations for pedestrians to gather, then a mixture of sitting and standing will be acceptable. However, seating areas will require the sitting classification. Balconies

and roof terraces are considered to have weather dependant use and therefore do not have a specific winter target.

9.36 Given the outline nature of the application, the intended use for the areas of interest from a wind microclimate perspective within the proposed development have not been defined. However, Figure 9.3 describes typical criteria that have been assumed to enable assessment. In summary, standing classification would be expected around buildings where entrances could be delivered; strolling classification would be expected in thoroughfares; sitting classification for amenity spaces; and sitting and standing for roof terraces.



	A	2 m/s	< 5%	Outdoor Dining
	B	4 m/s	< 5%	Pedestrian Sitting
	C	6 m/s	< 5%	Pedestrian Standing
	D	8 m/s	< 5%	Strolling
	E	10 m/s	< 5%	Walking
	U	10 m/s	> 5%	Uncomfortable

Figure 9.3: Proposed Development Assumed Intended Pedestrian Use

Strong Winds

- 9.37 Lawson also specifies a lower limit strong wind threshold when winds exceed 15 m/s for more than 2 hours of the year (Lawson LDDC Criteria). Exceedance of this threshold may indicate a need for mitigation measures or a careful assessment of the expected use of that location.
- 9.38 Strong winds are generally associated with areas which would be classified as acceptable for walking or as uncomfortable. Walking and uncomfortable conditions would not usually form part of the ‘target’ wind environment and would usually require mitigation due to pedestrian comfort and safety considerations. This mitigation would also reduce the frequency of, or even eliminate, any strong winds. Strong wind classification for the Lawson LDDC Criteria is given in Table 9.4.

Table 9.4: Lawson LDDC Criteria for Strong Wind Conditions				
Key		Wind Speed	% Time	Description
	A	2.5 m/s	< 5%	Frequent Sitting
	B	4.0 m/s	< 5%	Occasional Sitting
	C	6.0 m/s	< 5%	Standing
	D	8.0 m/s	< 5%	Walking
	E	8.0 m/s	> 5%	Uncomfortable
	S	15.0 m/s	> 0.022%	Unsafe

Significance Criteria

- 9.39 The significance criteria used in the assessment is based upon the relationship between the desired pedestrian use of a particular area of the proposed development, using the categories defined by the LCC, and the predicted wind conditions at that location. This allows for the assessment to take into account any change in pedestrian activity that might arise as a result of the proposed development.
- 9.40 A seven point scale has been used within this assessment to assess the significance of effects, as shown in Table 9.5.

Table 9.5: Significance Criteria	
Modelled Wind Microclimate Criteria	Scale of Effect
Wind Conditions are three categories calmer than desired	Major Beneficial
Wind Conditions are two categories calmer than desired	Moderate Beneficial
Wind Conditions are one category calmer than desired	Minor Beneficial
Wind Conditions are similar to those desired	Negligible
Wind Conditions are one category windier than desired	Minor Adverse
Wind Conditions are two categories windier than desired	Moderate Adverse
Wind Conditions are three categories windier than desired	Major Adverse

- 9.41 The adopted scale for the significance criteria is a logical comparison of the measured wind environment with the desired wind environment. An adverse effect implies that a location has a wind environment that is unsuitable for its intended use and mitigation should therefore be considered.
- 9.42 The minor, moderate and major categories indicate the scale of the difference between the desired microclimate and the actual microclimate. As an example, if the desired wind conditions at a particular location is required to be suitable for standing, but the predicted wind conditions are suitable for strolling, the difference between the desired and predicted wind condition is one category windier than desired. In this case, the significance of the effect would be identified as minor adverse. Any adverse

effect would be material to the planning decision process because it implies that a location, or area, has a wind microclimate that is unsuitable for the desired use of that area. Accordingly, minor to major adverse effects would be considered to be significant.

9.43 Wind effects due to development are usually ‘felt’ within the application site boundary or the immediate surrounding streets and are due to the building massing and orientation. Consequently, all reported effects are considered to be direct, local and long-term/irreversible unless there is a change in the massing or climate.

Assumptions and Limitations

- 9.44 Computational simulations have limitations to the scale and detail that can be represented in the computer model geometry. Building geometry is simplified such that footprint, height and only major features are represented. Similarly, smaller details such as trees, fencing, and street furniture were not included in the geometry model. With fewer obstructions to the air flow, this provides a “worst-case” wind scenario.
- 9.45 Care is needed when interpreting computationally derived wind data as the simulation methods have limitations. However, the SimScale LBM solver has been extensively validated against other simulation solvers and against wind tunnel and real-world measurements.
- 9.46 Meteoblue weather data is comprised of simulated data that can provide very accurate wind predictions for any given area. Though simulated, Meteoblue’s weather data has been compiled from hourly averages over a 30 year period and is regularly verified and tested against measured data. Alternatively, measured data can be very accurate but relies upon nearby weather stations for that to be the case. For example, Heathrow airport data is very complete but is 36 km from the application site which leads to significant regional calibration.
- 9.47 It is the authors’ opinion that the assumptions followed here represent a robust and thorough method of assessment.

Baseline Conditions

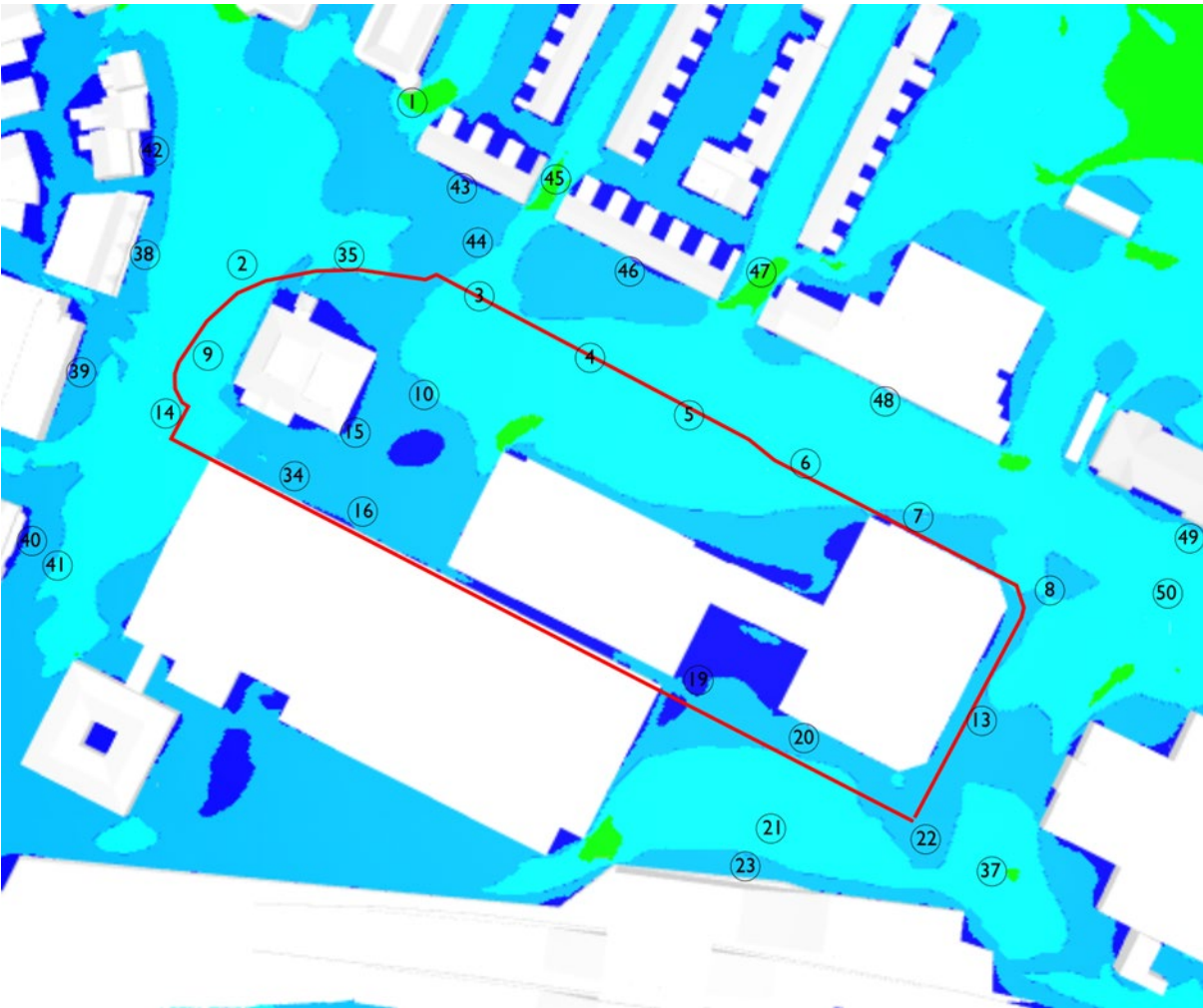
Existing Baseline

Configuration 1: Existing Baseline

- 9.48 The existing application site is characterised by two buildings. The smaller of the two buildings is single storey with a pitched roof, the larger building is formed of two interconnected structures approximately two storeys in height with a shallow pitched roof. The surrounding area is characterised by low rise residential and commercial development, typically of one to two storeys with pitched roofs. The existing on-site buildings are commercial and much of the outdoor space is allocated for car parking with some thoroughfares for access and areas around building entrances.
- 9.49 Wind conditions on the site are currently largely suitable for sitting or standing as shown in Figure 9.4. There are smaller areas suitable for outdoor dining and strolling. Detailed assessment of individual sensitive receptors is provided in the next section.

Strong Winds

- 9.50 There are no instances of winds exceeding 15 m/s for more than 0.025 % of the time in this configuration within or close to the application site.



	A	2 m/s	< 5%	Outdoor Dining
	B	4 m/s	< 5%	Pedestrian Sitting
	C	6 m/s	< 5%	Pedestrian Standing
	D	8 m/s	< 5%	Strolling
	E	10 m/s	< 5%	Walking
	U	10 m/s	> 5%	Uncomfortable

Figure 9.4: Configuration 1: Existing Baseline Pedestrian Comfort

Sensitive Receptors

Existing Sensitive Receptors

- 9.51 The existing sensitive receptors that could be affected by the proposed development are:
- pedestrians using thoroughfares around the application site (measurement locations 1,2,9 and 14 on Caversham Road, 35, 3-7 on Vastern Road, 8 and 13 on Troopers Port Way, 45 on De Montfort Road, and 47 on Lynmouth Road);
 - pedestrians using existing bus stop (measurement location 37);

- pedestrians using outdoor amenity spaces at the railway station entrance and drop off area (measurement location 21);
- entrances to residential buildings adjacent to the application site (measurement locations 38, 39, 40, 42, 43, 46, 48 and 49); and
- Pedestrians using pedestrian crossings (measurement locations 41, 44, and 50).

New Sensitive Receptors

- 9.52 The new sensitive receptors resulting from the introduction of proposed development would be: people entering and exiting the proposed development buildings; pedestrians using the new thoroughfares; and the users of the newly introduced open space and amenity area, both at ground level and at roof level.
- 9.53 The measurement locations presented in Figure 9.2 cover both existing receptors and new receptor locations.

Assessment of Effects
Demolition and Construction Effects

- 9.54 The proposed development would comprise the demolition of all existing buildings on-site. Demolition and construction works would be undertaken on a phased basis, as described in ES Chapter 5: Demolition and Construction Environmental Management.
- 9.55 Based upon professional judgement, the demolition and construction works are not anticipated to give rise to any significant change to the existing (relatively calm) wind microclimate both on and off-site.
- 9.56 The likely effect is therefore judged to be temporary **Negligible** and wind conditions both on and off-site would remain acceptable for their intended pedestrian uses. As construction of the proposed development proceeds, the wind conditions of the application site and its surrounds would gradually adjust to those described below for the completed development.

Completed Development Effects

Configuration 2: Existing Baseline + Proposed Development

- 9.57 The proposed development would deliver new buildings ranging in height from 93 m to 113 m. At ground level, areas of public realm and amenity space and four new thoroughfares would be delivered. New thoroughfares created by the proposed development plots are labelled as 1,2,3, and 4 in Figure 9.5.



Figure 9.5: Configuration 2 - Proposed Development Thoroughfares

Pedestrian Comfort

9.58 For Configuration 2, the modelled wind comfort conditions at ground level is shown in Figure 9.6.

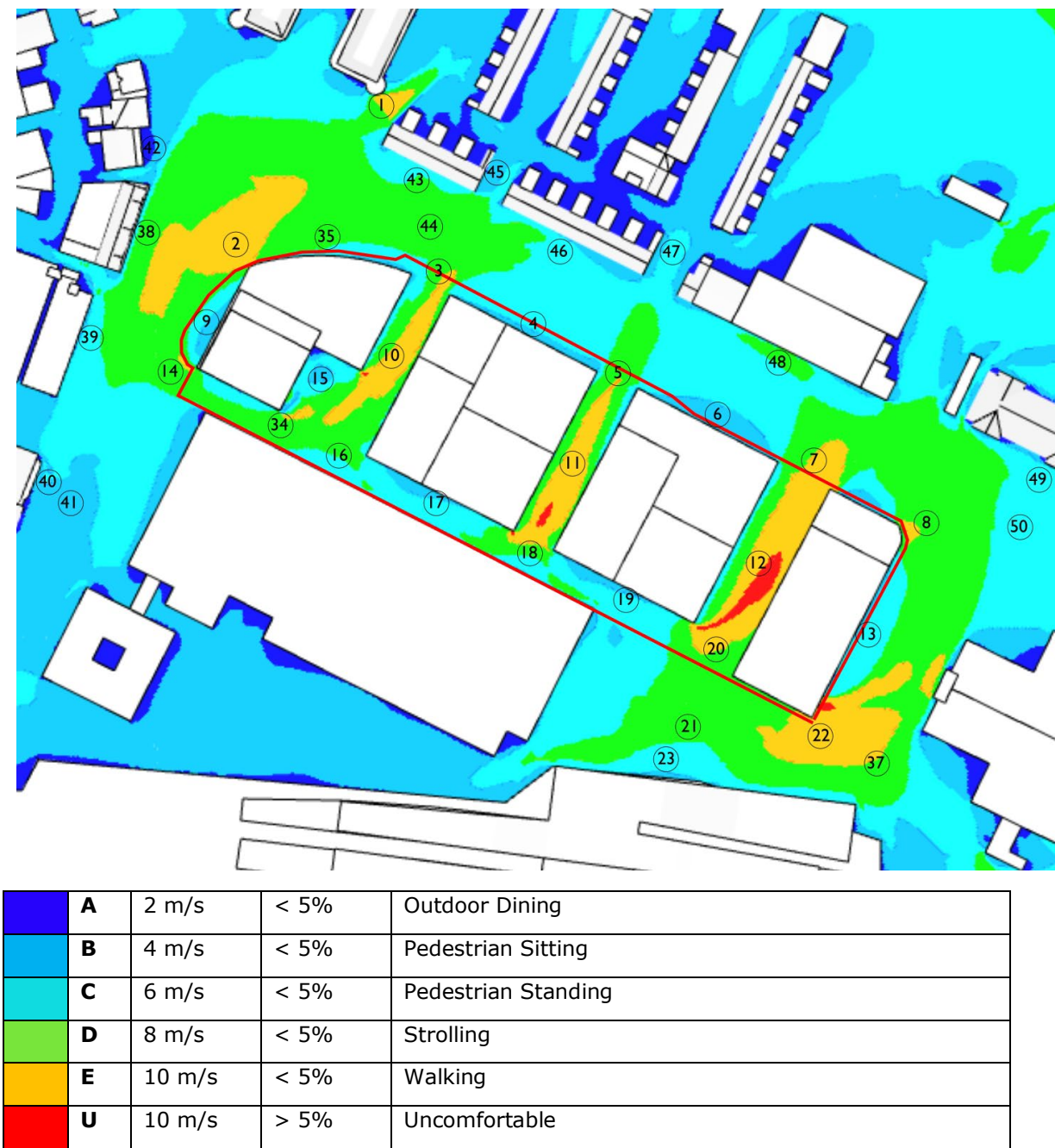


Figure 9.6: Configuration 2 – Ground Level (Pedestrian Comfort)

9.59 Wind conditions would range from being suitable for outdoor dining to being uncomfortable.

9.60 Specific receptor locations are discussed in more detail below.

Existing Off-Site Thoroughfares

9.61 Thoroughfares should typically be expected to have target conditions suitable for strolling/walking.

9.62 Measurement locations 3, 4, 6, 7 and 35 on Vastern Road would achieve the target wind conditions or better. Locations 3 and 5 would be windier than the baseline conditions (Configuration 1) and achieve

wind conditions suitable for walking, which is one category higher than the target. Therefore, the effects would range from **Negligible** to **Minor Adverse**.

9.63 At Troopers Port Way measurement locations 13 and 22 would achieve wind conditions for strolling/walking and therefore the effect would be **Negligible** to **Minor Adverse**.

9.64 Measurement locations 2, 9 and 14 along Caversham Road would achieve winds conditions of strolling/walking and therefore the effect would be **Negligible** to **Minor Adverse**.

9.65 At Brighams Mead, measurement location 1 the wind conditions would be suitable for walking and therefore the effect would be **Minor Adverse**.

9.66 At De Montfort Road, measurement location 45, the wind conditions would be suitable for walking and the effect would be **Minor Adverse**.

9.67 At Lynmouth Road, measurement location 47, the wind conditions would be suitable for walking and the effect would be **Minor Adverse**.

Proposed Development Thoroughfares

9.68 Measurement location 10 is on Thoroughfare 1. The wind conditions would range from being suitable for strolling/walking to being uncomfortable. Accordingly, the effect would range from **Negligible** to **Moderate Adverse**.

9.69 Measurement location 11 is on Thoroughfare 2. The wind conditions would be suitable for strolling/walking to being uncomfortable. Accordingly, the effect would range from **Negligible** to **Moderate Adverse**.

9.70 Measurement location 12 is on Thoroughfare 3. The wind conditions would be suitable for strolling/walking to being uncomfortable. Accordingly, the effect would range from **Negligible** to **Moderate Adverse**.

9.71 Measurement locations 34, 16, 17, 18, 19 and 20 are along Thoroughfare 4, the wind conditions at these locations would range from being suitable for standing to walking. Accordingly, the effect would range from **Minor Beneficial** to **Minor Adverse**.

Pedestrian Crossings

9.72 The target for pedestrian crossings would be to have conditions suitable for walking.

9.73 The pedestrian crossing at measurement location 41 on Caversham Road achieves sitting wind conditions, which is calmer than the target use and is a one category improvement against the baseline (Configuration 1) therefore a **Minor Beneficial** effect.

9.74 There are two pedestrian crossings on Vastern Road. The first is at measurement location 44 where wind conditions are suitable for strolling, which is two categories higher than the baseline conditions (Configuration 1), but one category lower than the target conditions and therefore suitable for its intended use. Accordingly, on balance, the effect is considered to be **Negligible**.

9.75 The second pedestrian crossing on Vastern Road is at measurement location 50, where wind conditions are suitable for standing, which is consistent with the baseline conditions and is suitable for the intended use. Accordingly, the effect would be **Negligible**.

Existing Off-Site Entrances

9.76 Entrances should typically provide shelter for pedestrians leaving a building and should have wind conditions suitable for standing.

9.77 There are four entrances to buildings on Caversham road (measurement locations 38, 39 and 40 and 42). Measurement location 38 would experience wind conditions suitable for strolling, which is a change from the baseline and one category higher that the target. Accordingly, the effect would be **Minor Ad-**

- verse.** Measurement location 39 would have wind conditions suitable for standing, which is a one category increase from the baseline conditions, but still appropriate for the intended use. The effect is therefore **Negligible**. Measurement location 40 would have wind conditions suitable for sitting, which is suitable for the intended use and consistent with the baseline conditions and therefore the effect would be **Negligible**. Measurement location 42 would have wind conditions suitable for outdoor dining, which is suitable for the intended use and consistent with the baseline conditions and therefore the effect would be **Negligible**.
- 9.78 On Vastern Road, the entrances at measurement location 43 would have wind conditions suitable for standing, which is a one category increase from the baseline conditions, but still appropriate for the intended use. The effect is therefore **Negligible**. The conditions for entrances at measurement location 45 would range from being suitable for sitting to standing, which is a one-two category improvement against the baseline and therefore the effect range from **Minor** to **Moderate Beneficial**. The entrance at measurement location 48 would have wind conditions suitable for strolling, which is a one category increase against the baseline and one category higher than the target. Therefore, the effect would be **Minor Adverse**. The entrance at measurement location 49 would have wind conditions suitable for standing, which is suitable for the intended use and consistent with the baseline conditions and therefore the effect would be **Negligible**
- 9.79 The entrance to the railway station at measurement location 23 experiences would experience wind conditions suitable for standing, which represents a **Negligible** effect.

Proposed Development Entrances

- 9.80 Entrances locations for the proposed development have not yet been defined. Modelled wind conditions at measurement locations 4, 6, 9, 13, 15, and 19 would be most suitable for entrances as they would achieve sitting to standing wind conditions which would be suitable for this use. Accordingly, the effect at these locations would be **Negligible**.
- 9.81 In the event that entrances are located along Thoroughfares 1, 2 and 3, or to the north of Building A and south of Building D, wind conditions would range from being suitable for strolling (measurement locations 16 and 35) to uncomfortable (measurement location 22). Accordingly, the effect would range from **Minor Adverse** to **Major Adverse**.

Off-site Bus Stops

- 9.82 The target wind conditions for a bus top should be standing.
- 9.83 The bus stop at measurement location 37 at the railway station would experience conditions suitable for walking, which is a change from the baseline and one category higher than the target. Accordingly, the effect would be **Minor Adverse**.

Off-Site Amenity Area

- 9.84 Target wind conditions for amenity spaces vary according to the intended use, but would be expected to range from sitting to standing.
- 9.85 The wind conditions at the sitting and pick-up area outside the railway station at measurement location 21 would experience conditions suitable for walking, which is a change from the baseline and is one to two categories higher than the target range. Accordingly, the effect would range from **Minor Adverse** to **Moderate Adverse**.

Proposed Development Ground Floor Amenity

- 9.86 The ground floor amenity areas and intended uses for the proposed development are not defined at this stage. Therefore, amenity space could come forward anywhere within the application site that is not covered by the footprints of Plots A-D. The wind conditions for this area would range from being suitable for outdoor dining (measurement location 15) to being uncomfortable (measurement location 12). When compared against the assumed target condition range of sitting to standing, the effect

would range from **Minor Beneficial** to **Major Adverse**. It is assumed that at the detailed design stage, the landscape strategy would design the amenity spaces such that the intended use accounts for the reported wind conditions and that mitigation measures, such as porous screening, would be employed in order to reduce wind conditions to the target levels.

- 9.87 At roof level, wind conditions would range from being suitable for outdoor dining use to being uncomfortable.

Proposed Development Roof Top Amenity

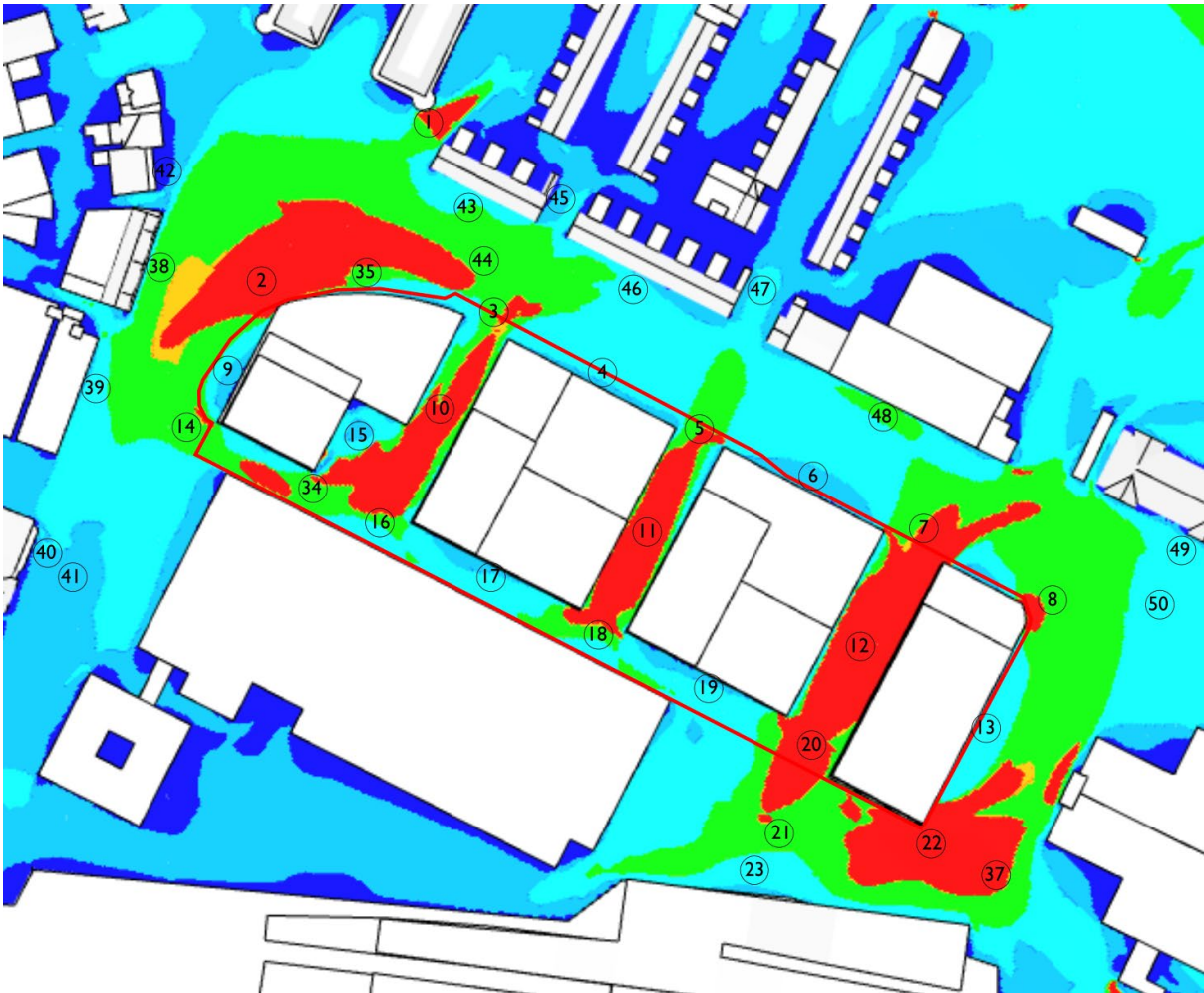
- 9.88 Wind conditions at the roof top level are shown in Figure 9.7. The wind conditions range from being suitable for outdoor dining to being uncomfortable. When compared against the assumed target condition range of sitting to standing, the effect would range from **Minor Beneficial** to **Major Adverse**.



Figure 9.7: Configuration 2 – Roof Level (Pedestrian Comfort)

Strong Winds

9.89 The Lawson safety criteria plot for strong winds at ground level is shown in Figure 9.8.

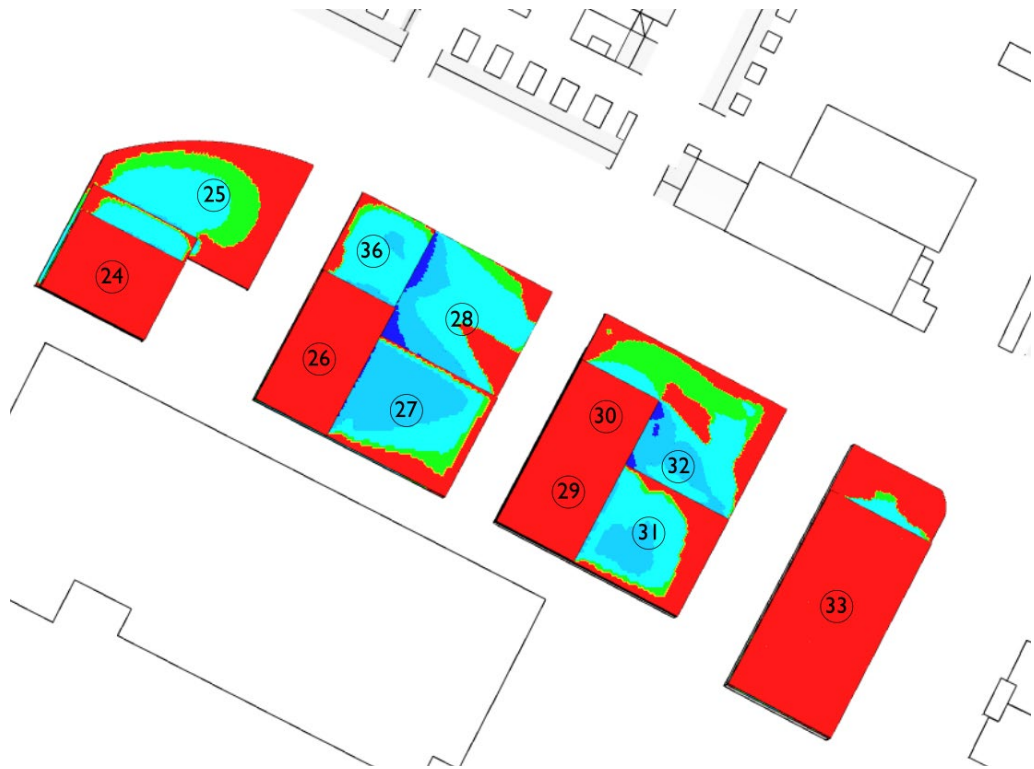


A	2.5 m/s	< 5%	Frequent Sitting
B	4.0 m/s	< 5%	Occasional Sitting
C	6.0 m/s	< 5%	Standing
D	8.0 m/s	< 5%	Walking
E	8.0 m/s	> 5%	Uncomfortable
S	15.0 m/s	> 0.022%	Unsafe

Figure 9.8: Configuration 2 – Ground Level (Strong Winds)

9.90 Unsafe, strong winds feature prominently at ground level within and surrounding the proposed development and at roof level. The new thoroughfares, 1, 2 and 3 are particularly affected, as demonstrated at measurement locations 10, 16, 3, 34, 11, 5, 18, 7, 12, 20 and 21, as well as the northern corner of Building A at measurement locations 2 and 35 and the southern corner of Building D at measurement locations 22 and 37. The north-east corner of Building D at location 8 is also expected to have unsafe strong winds.

- 9.91 The proposed development also introduces unsafe strong winds at the offsite thoroughfare at measurement location 1.
- 9.92 At roof level, strong winds would also occur, as shown in Figure 9.9. The upper roofs, measurement locations 24, 26, 29, 30, and 33 are the most severely affected. However, lower roofs, locations 25, 27, 28, 31, 32, and 36 feature rapid transitions from sitting and standing conditions to unsafe conditions at the building edges.
- 9.93 Mitigation is required to reduce the occurrence of 15 m/s or greater winds at these locations.
- 9.94 All instances of strong winds are considered to be **Major Adverse**.



A	2.5 m/s	< 5%	Frequent Sitting
B	4.0 m/s	< 5%	Occasional Sitting
C	6.0 m/s	< 5%	Standing
D	8.0 m/s	< 5%	Walking
E	8.0 m/s	> 5%	Uncomfortable
S	15.0 m/s	> 0.022%	Unsafe

Figure 9.9: Configuration 2 – Roof Level (Strong Winds)

Assessment of Residual Effects
Additional Mitigation

Demolition and Construction

9.95 No additional mitigation measures are required during the demolition and construction stage over and above those described in ES Chapter 5: Demolition and Construction Environment Management.

Completed Development

- 9.96 CFD testing of Configuration 2 highlights several locations which would experience conditions that would be windier than the assumed intended uses and target conditions and, therefore, would require mitigation in order to achieve the required wind conditions.
- 9.97 In addition, strong winds were recorded at 22 measurement locations throughout the proposed development. These locations would require measures to reduce the time winds exceed 15 m/s to less than 0.025 % of the time.
- 9.98 Given the outline nature of the proposals, and as is standard practice, during the detailed design consideration would be given to the following mitigation measures which would be explored and incorporated as part of the design:
 - Building form, scale and massing: Mitigation could be achieved by means of the articulation of the building scale, footprint and mass of the developments.
 - Elevational treatment: Fins, canopies, balustrades, arcades, screens can be used on buildings to slow and redirect wind flow preventing vertical flow down the building reaching pedestrian areas at ground level. Options would consider the potential for low-level ground winds being “trapped” under canopies preventing the air from escaping.
 - Recessed building entrances: Entrances can be recessed into buildings or built with screening nearby to provide an area of shelter for building users entering and exiting the buildings. Pedestrians are particularly sensitive when leaving a controlled environment so a sheltered region will allow time to acclimatise.
 - Screening: Screening in the form of sculptures which may be particularly useful to provide pedestrian shelter at sensitive areas such as entrances and seating areas. Porous screens allow some wind to penetrate but reduce the energy the wind contains, while solid screens can deflect the wind.
 - Landscaping: Landscaping can be a valuable tool to provide shelter. Raised and lowered terrain features can provide shelter and reduce exposure to the wind and break up air flow.
 - Planting: Planting should be relatively dense for maximum impact otherwise benefits will be relatively local. Semi-mature planting will provide some shelter from an early stage as the plants gain maturity. Whilst deciduous plants offer maximum shelter in summer months, this is greatly reduced to be negligible during windier winter months when the plant has shed its leaves. Trees and planting can provide not only fluctuations in airflow but also decrease wind speed. Greater mitigation can be expected from larger, well established trees.
 - Pergola Structures: Pergolas provide similar mitigation to planting and porous screening combining their effects. Pergolas can disrupt and slow airflow providing shelter.
- 9.99 Wind tunnel testing would be secured by means of an appropriately worded planning condition and undertaken at the detailed design stage to refine and demonstrate the effectiveness of these measures. The results of this assessment would be used to inform the design of the public realm to ensure that proposed uses achieve the required wind conditions.
- 9.100 Based on professional judgement and experience, the above listed measures could successfully mitigate the significant adverse and unsafe effects identified within this assessment.

Enhancement Measures

- 9.101 No enhancement measures are applicable for this assessment.

Demolition and Construction Residual Effects

- 9.102 The residual effects would remain temporary **Negligible**.

Completed Development Residual Effects

- 9.103 The results presented here are based upon a worst-case combination of annual wind conditions. The intention is to inform mitigation and detailed design decisions. It is reasonable to expect that spaces subject to seasonal use, such as outdoor seating areas, may see improvements (one category) when solely assessed against summer conditions. Such seasonal effects will be further assessed at the detailed design stage following wind tunnel testing.
- 9.104 The mitigation measures identified above would be developed at the detailed design stage by means of wind tunnel testing to be secured by means of an appropriately worded planning condition. However, at this outline stage, the effects remain as follows:
 - Existing off-site thoroughfares: Negligible – Minor Adverse
 - Proposed development thoroughfares: Negligible – Moderate Adverse
 - Pedestrian crossings: Negligible – Minor Beneficial
 - Existing off-site entrances: Moderate Beneficial – Minor Adverse
 - Proposed development entrances: Negligible – Major Adverse
 - Off-site bus stop: Minor Adverse
 - Off-site amenity area: Minor – Moderate Adverse
 - Proposed development ground floor amenity: Minor Beneficial – Major Adverse
 - Proposed development roof top amenity: Minor Beneficial – Major Adverse
- 9.105 Any adverse effect would be material to the planning decision process because it implies that a location, or area, has a wind microclimate that is unsuitable for the desired use of that area. Accordingly, minor to major adverse effects would be considered to be significant. As such, all receptor locations above would experience significant adverse effects.

Summary of Residual Effects

Table 9.10: Summary of Residual Wind Effects								
Receptor	Residual Effect	Additional Mitigation	Nature of Residual Effect*					
			Scale of Effect **	+ -	D I	P T	R IR	St Mt Lt
Demolition and Construction								
Pedestrians on-site and on off-site thoroughfares	Wind conditions suitable for strolling and walking	None	Negligible	N/A	D	T	R	St
Completed Development								
Pedestrians on Vastern Road	Wind conditions suitable for strolling and walking	Mitigation would be required and would be explored at the detailed design stage. This would include: articulation of the building form,	Negligible to Minor Adverse	N/A -	D	P	R	LT
Pedestrians on Caversham Road	Wind Conditions suitable for strolling and walking		Negligible to Minor	N/A -	D	P	R	LT
Pedestrians on Trooper Ports Way	Wind Conditions suitable for strolling and walking		Negligible to Minor	N/A -	D	P	R	LT

Table 9.10: Summary of Residual Wind Effects								
Receptor	Residual Effect	Additional Mitigation	Nature of Residual Effect*					
			Scale of Effect **	+ -	D I	P T	R IR	St Mt Lt
Pedestrians to Bingham's Mead	Wind conditions suitable for walking	scale and massing; screening; landscaping; and planting.	Minor	-	D	P	R	LT
Pedestrians to De Montford Road	Wind conditions suitable for walking		Minor	-	D	P	R	LT
Pedestrians to Lynmouth Road	Wind conditions suitable for walking		Minor	-	D	P	R	LT
Pedestrians on-site Thoroughfares 1 to 4	Wind Conditions suitable for strolling to Uncomfortable		Minor to Moderate	+ -	D	P	R	LT
Pedestrians using crossings	Wind Conditions range from suitable for sitting to strolling		Minor Negligible	+ N/A	D	P	R	LT
Pedestrians and building occupants using off-site building entrances	Wind Conditions range from suitable for outdoor dining to strolling		Moderate to Minor	+ -	D	P	R	LT
Pedestrians and building occupants using on-site building entrances	Wind Conditions suitable for standing to uncomfortable		Negligible to Major	N/A -	D	P	R	LT
Pedestrians using bus stop	Wind Conditions suitable for walking		Minor	-	D	P	R	LT
Pedestrians using station entrance	Wind Conditions suitable for walking		Minor to Moderate	-	D	P	R	LT
Users of on-site ground floor proposed development amenity areas	Wind Conditions range from suitable for outdoor dining to uncomfortable		Minor to Major	+ -	D	P	R	LT
Users of on-site roof level proposed development amenity areas	Wind Conditions range from suitable for outdoor dining to uncomfortable	Minor to Major	+ -	D	P	R	LT	
Notes:								
* - = Adverse/ + = Beneficial/ +/- Neutral; D = Direct/ I = Indirect; P = Permanent/ T = Temporary; R=Reversible/ IR= Irreversible; St- Short term/ Mt –Medium term/ Lt –Long term.								
**Negligible/Minor/Moderate/Major								

9.106 Where the pedestrian comfort assessment identified minor to major adverse effects, these are considered to be significant.

9.107 All instances of strong winds exceeding the 15m/s threshold are considered to be major adverse and significant.

Cumulative Effects

9.108 The following cumulative schemes are within close proximity to the application site and have the potential to lead to inter-project cumulative effects:

- Former BMW Site – Thames Quarter;
- Station Hill;
- 29 Station Road Reading;
- Network Rail Thames Valley Area site office/ Former Royal Mail site; and
- Former Scottish and Southern Energy site.

Demolition and Construction

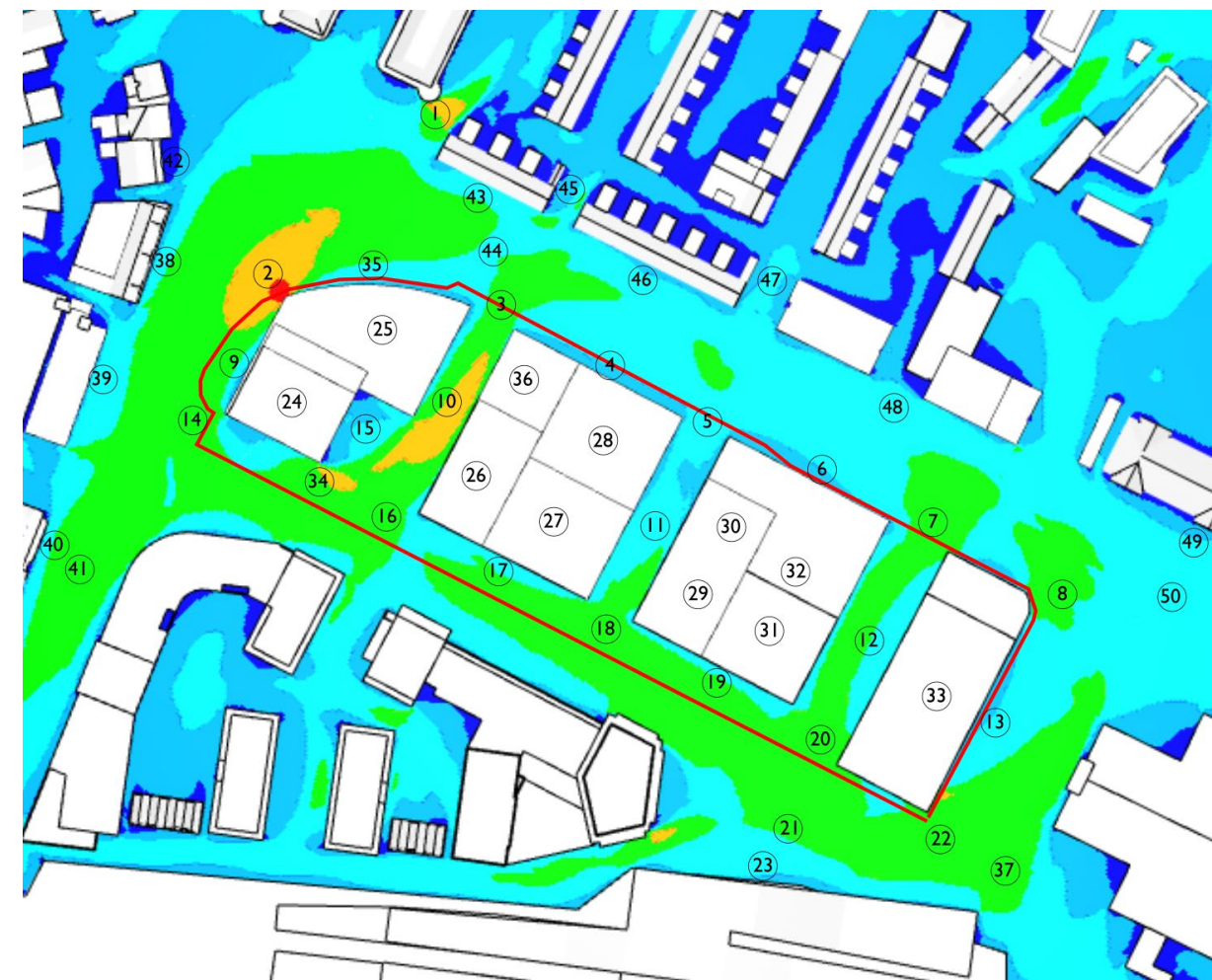
9.109 The cumulative scheme sites are currently occupied by low-rise buildings ranging from 1 to 5 storeys in height.

9.110 Based upon professional judgement, the demolition of the existing low-rise structures of the application site together with construction works at cumulative schemes in close proximity to the application site are not anticipated to give rise to any significant change to the existing (relatively calm) wind microclimate both on and off-site. The likely effect is therefore judged to be **Negligible** and wind conditions both on and off-site would remain acceptable for their intended pedestrian uses.

9.111 As construction of the proposed development and the above mentioned cumulative schemes proceed, the wind conditions of the application site and its surrounds would gradually adjust to those described below for the completed development.

Completed Development
Configuration 3: Existing Baseline + Proposed Development + Cumulative Schemes
Pedestrian Comfort

9.112 The combined pedestrian comfort effects resulting from the cumulative development of neighbouring sites are considered in this section. The Lawson Comfort Criteria plots for the proposed development + cumulative schemes is shown in Figure 9.10 for ground level.



A	2 m/s	< 5%	Outdoor Dining
B	4 m/s	< 5%	Pedestrian Sitting
C	6 m/s	< 5%	Pedestrian Standing
D	8 m/s	< 5%	Strolling
E	10 m/s	< 5%	Walking
U	10 m/s	> 5%	Uncomfortable

Figure 9.10: Configuration 3 - Ground Level (Pedestrian Comfort)

Existing Off-Site Thoroughfares

9.113 Following the introduction of the cumulative schemes, all off-site thoroughfare locations with the exception of measurement location 2, would achieve the target conditions or calmer and therefore the effects would be **Negligible**. Measurement location 2 would experience uncomfortable conditions, which is two to three categories windier than the target conditions and therefore the effect would range from **Moderate to Major Adverse**.

Proposed Development Thoroughfares

9.114 Following the introduction of the cumulative schemes, thoroughfares two, three and four within the application site would achieve the target conditions or calmer and therefore the effects would be **Minor Beneficial to Negligible**. Thoroughfare one would continue to experience wind conditions suitable for walking use and therefore the effect would remain **Minor Adverse**.

Pedestrian Crossings

Following introduction of the cumulative schemes, the wind conditions and effects on the pedestrian crossings would achieve the target conditions or calmer and therefore the effects are **Moderate to Minor Beneficial**.

Existing Off-Site Entrances

9.115 All off-site entrances would achieve the required conditions or calmer. Accordingly, the effects are **Moderate Beneficial to Negligible**.

Proposed Development Entrances

- 9.116 Entrances locations for the proposed development have not yet been defined. Measurement locations 4, 6, 9 and 15 would remain the most suitable points for entrances with either sitting or standing wind conditions which are suitable for this use. The cumulative effects here would be **Negligible to Minor Beneficial**.
- 9.117 Wind conditions at measurement locations 9 and 19 change from standing use to suitable for strolling use, a **Minor Adverse** effect when compared to target conditions.
- 9.118 Around measurement location 11, conditions improve from walking use to standing use, a **Negligible** effect when compared to target conditions making this location suitable for an entrance.

Off-site Bus Stops

9.119 The bus stop at measurement location 37 at the railway station would improve from walking use to strolling use, a **Minor Adverse** effect when compared to target conditions.

Off-Site Amenity Areas

9.120 The wind conditions at the sitting and pick-up area outside the railway station at measurement location 21 would remain suitable for walking use representing a **Moderate Adverse** effect when compared to target conditions.

Proposed Development Ground Floor Amenity

9.121 The wind conditions around development Buildings A to B would remain varied with areas suitable for outdoor dining to uncomfortable. The cumulative effects when compared to target conditions therefore range from **Minor Beneficial to Major Adverse**.

Proposed Development Roof tops

9.122 Wind conditions at the roof top level would range from being suitable for outdoor dining to being uncomfortable. When compared against the assumed target condition range of sitting to standing, the cumulative effect would range from **Minor Beneficial to Major Adverse**.

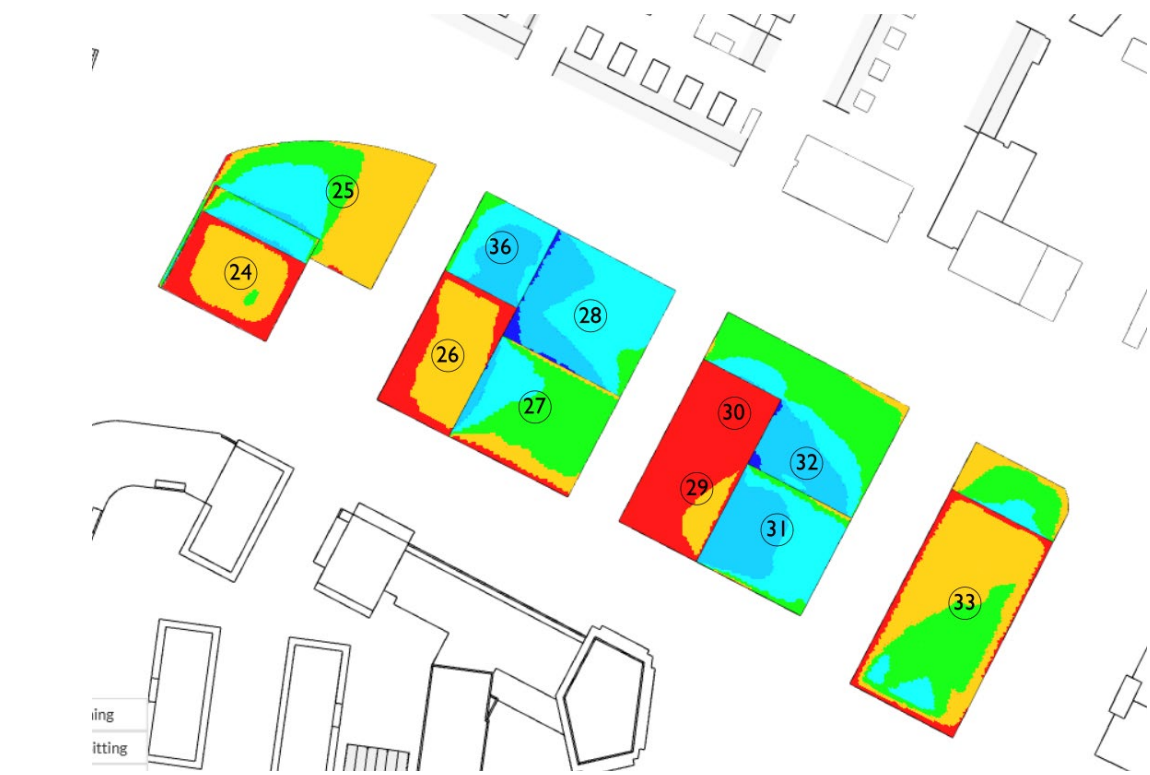


Figure 9.11: Configuration 3 - Roof Level (Pedestrian Comfort)

Strong Winds

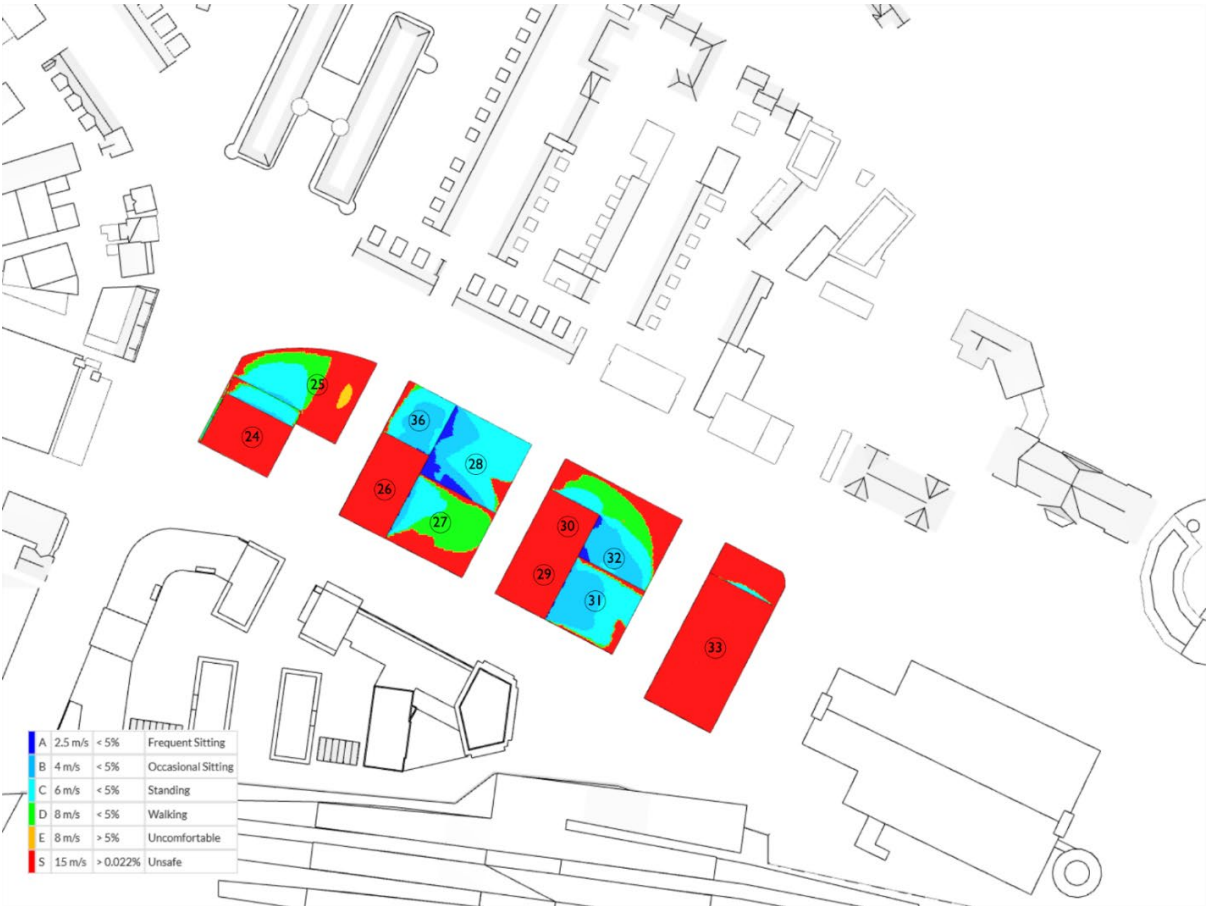
The Lawson Safety criteria plots for strong wind for the development + cumulative schemes is shown in Figure 9.12 for ground level, and Figure 9.13 for roof top level.



	A	2.5 m/s	< 5%	Frequent Sitting
	B	4.0 m/s	< 5%	Occasional Sitting
	C	6.0 m/s	< 5%	Standing
	D	8.0 m/s	< 5%	Walking
	E	8.0 m/s	> 5%	Uncomfortable
	S	15.0 m/s	> 0.022%	Unsafe

Figure 9.12: Configuration 3 - Ground Level (Strong Winds)

- 9.123 The impact of strong winds would be reduced by the cumulative schemes, although several large areas of unsafe wind conditions would remain unchanged around measurement locations 2, 10, 12, 22, 34.
- 9.124 Measurement locations 3, 7, 16, 18, 20, 21, and 37, improve from being unsafe to walking safety.
- 9.125 Measurement locations 5, and 11 reduce from being unsafe to standing safety levels.
The unsafe wind conditions on the roof tops remain similar to the configuration 2 conditions.



	A	2.5 m/s	< 5%	Frequent Sitting
	B	4.0 m/s	< 5%	Occasional Sitting
	C	6.0 m/s	< 5%	Standing
	D	8.0 m/s	< 5%	Walking
	E	8.0 m/s	> 5%	Uncomfortable
	S	15.0 m/s	> 0.022%	Unsafe

Figure 9.13: Configuration 3 - Roof Level (Strong Winds)